

# Health Status of Workers Exposed to Phthalate Plasticizers in the Manufacture of Artificial Leather and Films Based on PVC Resins\*

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The industry under consideration uses chiefly the phthalate plasticizers: predominantly dibutyl phthalate (DBP) and higher alkyl phthalates (DAP-789); periodically dioctyl phthalate (DOP), diisooctyl phthalate (DIOP), and benzyl butyl phthalate (BBP). Some formulations contain small amounts of one of the sebacates (dibutyl sebacate, DBS, or dioctyl sebacate, DOS) or adipates (dibutyl adipate, DBA, or dioctyl adipate, DOA). Tricresyl phosphate (TCP) was a component of the incombustible materials produced in 10–20% of machines assigned to various workers. The literature data on the toxicity of phthalates are sparse and contradictory (1–9).

In order to clarify the question of the possibility that chronic occupational intoxication could arise under manufacturing conditions and to ascertain the role of phthalate plasticizers in this connection, we studied 147 persons (87 women and 60 men), the majority of them (75%) not more than 40 years old. The duration of occupational contact with the plasticizers was ½–5

yr for 54 persons, 6–10 yr for 28 workers, and > 10 yr (up to a maximum of 19 yr) for 65 persons. Among the persons under study there were 60 primers, 28 calender and mill operators, 35 mixing-apparatus operators and paint millers, 24 inspectors of final production and winders.

The ambient levels of vapors or aerosols of the plasticizers (mixed esters) at the working zone of the primers ranged from 10 to 66 mg/m<sup>3</sup>. Similar results were obtained at the work stations of the mill operators and calender operators.

In the mixture preparation section, the plasticizer level was found to be 1.7–40 mg/m<sup>3</sup>. The levels of vinyl chloride, carbon monoxide, and hydrogen chloride in work zones around the calenders and rollers did not exceed the maximum allowable concentration, and in many samples these compounds were not detected at all. Thus, the principal components of the gaseous environments in the factories were the phthalate plasticizers.

In addition to the usual analytical methods, we also used a set of special procedures: algometry, olfactometry, audiometry, investigation of sensitivity to vibration, and study of the vestibular func-

\*Translated from *Gigiena Truda*. 13:14 (1969).

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tion by the caloric method with cold water (60 ml at 19°C for 20 sec). Clinical and biochemical blood studies (sedimentation rate, bilirubin level) were also performed. Changes in the nervous system, sensory receptor organs, and peripheral blood were of the same type in the primers, calender operators, mill operators, and paint millers and were dependent on the duration of contact with the plasticizers.

The most frequently cited complaint was of pain in the upper and lower extremities (reported in 57.1% of the cases with a length of service of 6–10 yr, in 81.6% of cases with a length of service of more than 10 yr), accompanied by numbness and spasms. The pain and numbness usually developed after 6–7 yr of work and were generally first noted at rest, at night. With increasing length of service, the pain became continuous, and the subjects began to experience weakness and pain in the legs while walking (especially at the beginning of a walk or while climbing a staircase). A number of the subjects with long-term exposure developed attacks of weakness in the extremities, manifested by dropping objects from their hands, and periodic “twisting” of the feet while walking.

Studies of the nervous system revealed polyneuritis in 47 persons (32 with an autonomic-sensory form and 15 with a mixed form). The incidence of polyneuritis increased with the length of service. Functional disturbance of the nervous system was noted in 22 workers (15%). In 3.4% of the cases, organic disease of a nonoccupational character was noted in the nervous system. Half of the persons studied (49.6%) were classified as essentially healthy.

The autonomic-sensory polyneuritis was characterized by pain and numbness of the extremities, chiefly while at rest, accompanied by vegetative-sensory disturbances. In a number of cases there were changes in the muscles of the shoulder girdle which were apparently related to physical stress on the arms. In the mixed motor-sensory form of polyneuritis, the signs in question were accompanied by depression and asymmetry

of the tendon reflexes, especially the Achilles, and in some cases by slight paresis, atrophy, and fasciculation. Changes in the Achilles reflexes were shown by 19.4% of the workers with service periods of more than 10 yr. The association of polyneuritis, disturbances with signs of pyramidal insufficiency in the form of dissociation of tendon reflexes (exaggerated patellar and depressed Achilles reflexes), pathologic Rossolimo and Zhukovskii signs, and withdrawal reflexes involving hands and feet served as a basis for the diagnosis of spinal polyneuritis (myelopolyneuritis) in three workers. In addition to the polyneuritis, five persons had brain stem disturbances in the form of nystagmus, insufficiency of the VII cranial nerves, etc. (cranial nerve polyneuritis).

In the study of sensitivity to pain, an elevation of the threshold was noted in 66.7% of the subjects. The polyneuritic type of disturbance of sensitivity predominated among workers with service periods of 4–10 yr, while the workers with service periods in excess of 10 yr often exhibited both the polyneuritic or segmental-radicular type of disturbance and manifestations of general hypalgesia of a total character or partial, sparing certain regions of the body (oral, anal, etc.). Variability of the intensity and combination of the zones of disturbance, usually on the trunk, head, and the proximal regions of the extremities, can serve in differentiating between neurointoxications and organic diseases of the nervous system caused by damage to the ascending sensory pathways.

The sensitivity to vibrations was lowered to some extent in 33.8% of the subjects under study, but a marked depression of the values was seen only in those persons also manifesting a significant depression of the sensitivity to pain. Unlike the disturbance in sensitivity to pain, the disturbance of sensitivity to vibrations correlated in degree with the severity of the polyneuritis. In the cases of marked autonomic-sensory forms of polyneuritis, electromyograms of those workers studied in the hospital showed typical shifts

indicative of involvement of the anterior horn of the spinal cord. The severity of the initial forms of polyneuritis was also indicated by the attacks of weakness in the extremities seen in workers with long service periods.

Of 81 persons undergoing investigation of the vestibular receptors, 78% were found to have depression of the vestibulosomatic reactions (absence or lowering of excitability). This depression began with the first years of occupational contact with the plasticizers, often in the absence of any complaints as to the subject's state of health. Many workers with long service periods often showed a combination of depression of vestibular functions with a heightening of vestibulo-autonomic reactions in the form of nausea, vomiting, vertigo, facial hyperemia, and pallor. As we know, such a dissociation of reactions is indicative of extralabyrinthine disorders and can be used as an early test for subclinical autonomic-vascular disorders.

When tested by olfactometry, the majority of the subjects studied showed an elevation of the threshold of excitability, especially for thymol (82.1% of subjects), and camphor and tar (50%), and less for rosemary (33.4%, most often among workers with long service). The elevation of the threshold of excitability of the olfactory receptors began with the first years of work and increased with increasing duration of service.

A study of the threshold of auditory sensitivity by the use of audiometry did not reveal any pathology.

Hypertensive reactions and hypertensive disease were discovered in 28.3 and 6%, respectively, of the subjects examined. The frequency of hypertensive reactions rose somewhat with an increase in the length of service. In a number of cases, angiopathy of the retina was discovered, even in the absence of elevated blood pressure.

Study of the blood revealed a tendency to slight lowering of the number of platelets and leukocytes (neutropenia with relative lymphocytosis), the hemoglobin level, and the blood color index. There was slight

reticulocytosis and a tendency to acceleration of the erythrocyte sedimentation rate among the females (statistically significant changes). The shifts in the number of leukocytes, platelets, and reticulocytes predominated among the workers with long service. A moderately pronounced hyperbilirubinemia accompanied by a normal mercuric chloride test was found in 8% of the cases.

The question of transfer to work without contact with toxic substances for subjects with autonomic-sensory polyneuritis must be settled individually, with due consideration of the severity and stability of the pain syndrome, knowledge of the general anatomicophysiological patterns of disorders of sensitivity (e.g., the mediopolar and mediopolar regions are extinguished later than the external surfaces of the extremities). Helpful in the diagnosis and expert evaluation are the extinction of the Achilles reflexes and substantial decrease in sensitivity to vibration, together with the electromyographic findings. Workers who have been diagnosed as having the initial signs of polyneuritis should be placed under observation and treatment, in some cases with temporary transfer to work without contact with toxic substances. Subjects with more pronounced forms of polyneuritis should be transferred to suitable work not involving contact with toxic substances and should be considered for appropriate compensation in accord with VTEK [Court of Medical Referees for Industrial Disability] guidelines where such placement is impossible.

## Conclusions

In a study of the health status of workers subjected to prolonged exposure to phthalate plasticizers, occupational illnesses were discovered that appeared in the form of a moderately pronounced toxic polyneuritis, the frequency and degree of which increased with the length of stay on the job.

An investigation of the sensory functions revealed an early lowering of the excitability of the vestibular and olfactory receptors and of cutaneous sensitivity.

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